CORDIERITE FILTERS WITH REDUCED PRESSURE DROP

BACKGROUND OF THE INVENTION

[0001]   The present invention relates to diesel particulate filters; and in particular to cordierite wall-flow diesel particulate filters having high filtration efficiency, high strength and low pressure drops for catalyzed and uncatalyzed applications.

[0002]   Porous, wall-flow ceramic filters have been utilized for the removal of carbonaceous soot particles from the exhaust stream of diesel engines since the early 1980s. A porous ceramic diesel particulate filter (DPF) ideally combines low CTE (for thermal shock resistance), low pressure drop (for engine efficiency and fuel economy), high filtration efficiency (for removal of most particles from the exhaust stream), high strength (to survive handling, canning, and vibration in use), and low cost. Cordierite has satisfied these requirements; however, benefit would be gained by further reducing the pressure drop of commercially available cordierite DPFs.

[0003]   During use, the pressure drop of a ceramic filter increases as diesel particulate material or carbon soot is deposited within the filter. Typically, during the deposition of the first 0.5 to 1.0 gram/liter of soot, the increase in pressure drop is especially rapid. This has been attributed to the penetration of soot into the surface and near-surface pores of the filter walls. The presence of soot within the filter walls lowers the overall permeability of the wall, thereby increasing the resistance of gas flow through the wall and increasing the pressure drop across the filter. Once the surface and near-surface pores are filled with the porous soot deposit, additional soot accumulates on the outer surface of the walls of the inlet channels as a discrete porous soot layer, or "soot cake." Although the permeability of this soot layer is very low, the rate of increase in pressure drop per unit mass of deposited soot is actually lower during the soot layer formation stage than during the initial stage in which soot penetrates the filter wall. Periodically, the soot must be burned out of the filter, in situ, in order to prevent clogging of the filter and to restore the filter to a low pressure drop state. This process is known as "regeneration" of the filter.

[0004]   A recent trend in pollution control for diesel engines has been the application of a catalyst system to the DPF in order to promote the conversion of carbon monoxide and unburned hydrocarbons in the exhaust stream to carbon dioxide and water. These catalyst

systems are generally comprised of a mixture of a highly dispersed noble metal catalyst supported on a high surface area metal oxide. The catalyst system may be present as a "washcoat" on the outer surfaces of the filter wall, but more typically resides primarily within the pores of the filter walls, where the oxides + metals form a thin coating that lines the surfaces of the pore walls.

[0005]   In addition to catalyzing gas reactions, the catalysts can serve to lower the temperature at which the accumulated soot undergoes combustion during regeneration or can otherwise facilitate the regeneration of the filter. Regeneration of the filter requires that the temperature of the exhaust stream entering the filter be raised to the point at which the soot begins to burn. Various strategies have been adopted to provide this energy, all of which reduce the fuel efficiency of the vehicle. Thus, by reducing the energy that must be supplied in order to light-off of the soot, the catalyst can provide benefits in fuel efficiency and cost savings over the life of the vehicle.

[0006]   It has been observed, however, that the application of a catalyst system to a DPF causes an increase in the pressure drop across the clean and soot-loaded filter. This is due to a reduction in the porosity and a change in the pore size distribution and pore connectivity of the filter with the application of the catalyst system. This change in pore microstructure reduces the permeability of the clean wall prior to soot loading, and also reduces the permeability of the soot-containing wall for any given mass of soot. In attempting to offset an increase in pressure drop observed in catalyzed filters it has been suggested to increase the porosity and median pore size. However, this combination of high porosity and large pore size causes lower filtration efficiency and lower mechanical strength, and does not yield an optimized filter. Furthermore, non-uniform distribution of the catalyst can result from broad pore size distributions.

[0007]   A high-porosity cordierite DPF that provides a lower pressure drop in both the catalyzed and uncatalyzed state relative to filters that have been previously demonstrated, while maintaining high filtration efficiency and sufficient mechanical strength, would be an advancement in the art. The present invention provides such a cordierite DPF and a method of making the same.

SUMMARY OF THE INVENTION

[0008]   In one aspect of the invention there is provided a diesel particulate filter comprising a plugged, wall-flow honeycomb filter body composed of cordierite and having a plurality of parallel end-plugged cell channels traversing the body from a frontal inlet end to an outlet end thereof, wherein the filter exhibits: (a) a CTE (25-800°C) of less than $13 \times 10^{-7}/°C$, preferably less than $10 \times 10^{-7}/°C$, more preferably less than $7 \times 10^{-7}/°C$, even more preferably greater than $4 \times 10^{-7}/°C$ and less than $13 \times 10^{-7}/°C$, even more preferably greater than $4 \times 10^{-7}/°C$ and less than $10 \times 10^{-7}/°C$, and even more preferably greater than $4 \times 10^{-7}/°C$ and less than $7 \times 10^{-7}/°C$; (b) a bulk filter density of less than 0.60 g/cm^3; (c) a median pore diameter, d_{50}, of less than 25 micrometers, and a porosity and pore size distribution that satisfy the relationship $P_m \leq 3.75$, preferably $P_m \leq 3.50$, preferably $P_m \leq 3.30$, wherein P_m is equal to $10.2474\{1/[(d_{50})^2 (\%porosity/100)]\} + 0.0366183(d_{90}) - 0.00040119(d_{90})^2 + 0.468815(100/\%porosity)^2 + 0.0297715(d_{50}) + 1.61639(d_{50} - d_{10})/d_{50}$, wherein d_{10}, and d_{90} are pore diameters in micrometers at 10% and 90% of the pore size distribution based upon volume, and $d_{10} < d_{50} < d_{90}$. The inventive diesel particulate filter is suitable for both catalyzed and uncatalyzed applications. Preferred embodiments of the inventive diesel particulate filter are further described below.

[0009]   In another aspect of the invention there is provided a method of making a cordierite structure for use in a diesel particulate filter, the method comprising: forming a mixture of cordierite-forming raw materials, a pore former and organic components, the cordierite-forming raw materials including talc, silica, an alumina-forming source, and optionally kaolin, each defining a median particle size, wherein the talc median particle size, the alumina-forming source median particle size, the pore former, and a pore former median particle size satisfy the relationship $R_m \leq -2.64$, where R_m is equal to $[-0.102(\text{talc median particle diameter}) + 0.001466(\text{talc median particle diameter})^2 - 0.0491((\text{weight percent super-addition of pore forming agent})/(\text{density of pore forming agent})) - 0.00762(\text{median particle diameter of pore forming agent}) + 0.0000760(\text{median particle diameter of pore forming agent})^2 - 0.0562(\text{median particle diameter of the alumina-forming source})]$; shaping the mixture into a green structure; and, firing the green structure at a temperature and for a time to produce a fired structure. Median particle diameters are in micrometers and density is in

grams per cubic centimeter. Preferred embodiments of the inventive forming method are further described below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] A complete understanding of the present invention may be obtained by reference to the accompanying drawings, when considered in conjunction with the subsequent detailed description, in which:

[0011] FIG. 1 is a graphical representation of the pressure drop value between the inlet and outlet ends of comparative filters (open circles) and inventive filters (filled circles), measured at a flow rate of 11.25 scfm of air at 25°C, as a function of the amount of dry, artificial carbon soot that was previously loaded into the filter at a flow rate of 15 scfm; all filters have approximately the same external dimensions (2 inches diameter, 6 inches long) and about the same cell densities (165-215 cells/in^2);

[0012] FIG. 2 is a graphical representation of the pressure drop value between the inlet and outlet ends of comparative filters (open circles) and inventive filters (filled circles), measured at a flow rate of 11.25 scfm of air at 25°C on 2 inch diameter by 6 inch long filters (165-215 cpsi) and at 5 grams/liter dry artificial carbon soot loading (deposited at a flow rate of 15 scfm), versus the pore microstructure parameter P_m;

[0013] FIG. 3 is a graphical representation of the pressure drop value between the inlet and outlet ends of comparative filters (open circles) and inventive filters (filled circles), measured at a flow rate of 11.25 scfm of air at 25°C on 2 inch diameter by 6 inch long filters (165-215 cpsi) and at 5 grams/liter dry artificial carbon soot loading (deposited at a flow rate of 15 scfm), versus the percent of the total porosity that lies between 10 and 50 μm; and,

[0014] FIG. 4 is a graphical representation of the relationship between the pressure drop value between the inlet and outlet ends of comparative filters (open circles) and inventive filters (filled circles), measured at a flow rate of 11.25 scfm of air at 25°C on 2 inch diameter by 6 inch long filters (165-215 cpsi) and at 5 grams/liter dry artificial carbon soot loading (deposited at a flow rate of 15 scfm), versus the raw material parameter R_m.

DETAILED DESCRIPTION OF THE INVENTION

[0015]   Cordierite diesel particulate filters according to the present invention have an enhanced pore microstructure that is optimized for pore connectivity and uniform pore size distribution that results in significant reduction in pressure drop while maintaining mechanical strength and high filtration efficiency. Accordingly, the porosity and pore size distribution satisfy the relationship $P_m \leq 3.75$, in which P_m is computed as $10.2474\{1/[(d_{50})^2 (\%Porosity/100)]\} + 0.0366183(d_{90}) - 0.00040119(d_{90})^2 + 0.468815(100/\%Porosity)^2 + 0.0297715(d_{50}) + 1.61639(d_{50}-d_{10})/d_{50}$. The values of d_{10}, d_{50} and d_{90} are in units of micrometers, %porosity is dimensionless, where pore sizes and porosity are measured by mercury porosimetry. The values of d_{10}, d_{50}, and d_{90} are the pore diameters at 10%, 50%, and 90% of the total pore size distribution on a volumetric basis. Specifically, d_{10} is the pore diameter at 90% cumulative mercury intrusion volume, d_{50} is the pore diameter at 50% cumulative mercury intrusion volume, and, d_{90} is the pore diameter at 10% cumulative mercury intrusion volume. Thus, 10% of the pores are smaller than d_{10}, 50% of the pores are smaller than d_{50}, and 90% of the pores are smaller than d_{90}, on a volumetric basis. The value of d_{50} is less than 25 μm.

[0016]   In order to achieve lowest soot-loaded pressure drops, the value of P_m is preferably not greater than 3.50, and more preferably not greater than 3.30. To achieve the excellent pore connectivity that is associated with low soot-loaded pressure drop and low values of P_m, the %porosity is preferably not less than 53%, more preferably not less than 56%, and most preferably not less than 59%. Likewise, the value of $(d_{50}-d_{10})/d_{50}$ is preferably not greater than 0.60, more preferably not greater than 0.50, and most preferably not greater than 0.45. For high filtration efficiencies and high strength, the value of d_{50} is preferably less than 20 μm, more preferably less than 15 μm, and most preferably less than 12 μm. For similar reasons, the value of d_{90} is preferably less than 40 μm, more preferably less than 30 μm, and most preferably less than 20 μm.

[0017]   The inventive filters further exhibit a CTE (25-800°C) of less than $13 \times 10^{-7}/°C$, preferably less than $10 \times 10^{-7}/°C$, more preferably less than $7 \times 10^{-7}/°C$, even more preferably greater than $4 \times 10^{-7}/°C$ and less than $13 \times 10^{-7}/°C$, even more preferably greater than $4 \times 10^{-7}/°C$ and less than $10 \times 10^{-7}/°C$, and even more preferably greater than $4 \times 10^{-7}/°C$ and less than $7 \times 10^{-7}/°C$, and a bulk filter density of less than 0.60 g/cm^3. A high a modulus of rupture, as

measured by the four-point method on a cellular bar cut parallel to the direction of the channels, is also provided of preferably at least 200 psi, more preferably at least 250 psi, and most preferably at least 300 psi.

[0018] In an embodiment, the inventive cordierite diesel particulate filter exhibits a CTE (25-800°C) of less than $13 \times 10^{-7}/°C$, a bulk filter density of less than 0.60 g/cm^3, and a pressure drop in kPa across the filter, as measured at 25°C and a flow rate of 11.25 scfm on a 2 inch diameter, 6 inch long filter having about 200 cpsi and a 0.012 inch wall thickness, of not more than 2.2 kPa when the filter contains 5 grams/liter of dry artificial carbon soot that was previously loaded onto the filter at a flow rate of about 15 scfm. The pressure drop as measured under these conditions is preferably not greater than 1.8 kPa, more preferably not greater than 1.5 kPa, and most preferably not greater than 1.3 kPa. The CTE (25-800°C) is preferably less than $10 \times 10^{-7}/°C$, more preferably less than $7 \times 10^{-7}/°C$, even more preferably greater than $4 \times 10^{-7}/°C$ and less than $13 \times 10^{-7}/°C$, even more preferably greater than $4 \times 10^{-7}/°C$ and less than $10 \times 10^{-7}/°C$, and even more preferably greater than $4 \times 10^{-7}/°C$ and less than $7 \times 10^{-7}/°C$. In regards to the artificial carbon soot, the term "dry" signifies that the soot does not contain substantial amounts of adsorbed volatile organic compounds.

[0019] In another embodiment, the inventive cordierite diesel particulate filter exhibits a CTE (25-800°C) of less than $13 \times 10^{-7}/°C$, a bulk filter density of less than 0.60 g/cm^3, and a pressure drop in kPa across the filter, as measured at 25°C and a higher flow rate of 26.25 scfm on a 2 inch diameter, 6 inch long filter having about 200 cpsi and a 0.012 inch wall thickness, of not more than 5.8 kPa when the filter contains 5 grams/liter of dry artificial carbon soot that was previously loaded onto the filter at a flow rate of about 15 scfm. The pressure drop as measured under these conditions is preferably not greater than 5.0 kPa, more preferably not greater than 4.5 kPa, and most preferably not greater than 4.0 kPa. The CTE (25-800°C) is preferably less than $10 \times 10^{-7}/°C$, more preferably less than $7 \times 10^{-7}/°C$, even more preferably greater than $4 \times 10^{-7}/°C$ and less than $13 \times 10^{-7}/°C$, even more preferably greater than $4 \times 10^{-7}/°C$ and less than $10 \times 10^{-7}/°C$, and even more preferably greater than $4 \times 10^{-7}/°C$ and less than $7 \times 10^{-7}/°C$.

[0020] The present invention also includes a wall-flow filter comprising a cordierite body having a CTE (25-800°C) of less than $13 \times 10^{-7}/°C$, a bulk filter density of less than 0.60 g/cm^3, and a pressure drop at 1.0 gram/liter of soot loading that is not more than 0.75 kPa greater than the pressure drop of the clean (soot-free) filter when the pressure drop is

measured at about 25°C at a flow rate of 11.25 scfm across a 2-inch diameter by 6-inch long portion of a filter having about 200 cells/inch^2 and a wall thickness of about 0.012 inches, and the soot is an a dry artificial soot that was previously loaded onto the filter at a flow rate of 15 scfm. The pressure drop difference as measured under these conditions is preferably less than 0.6 kPa, more preferably less than 0.5 kPa, and most preferably less than 0.4 kPa. The CTE (25-800°C) is preferably less than $10x10^{-7}$/°C, more preferably less than $7x10^{-7}$/°C, even more preferably greater than $4x10^{-7}$/°C and less than $13x10^{-7}$/°C, even more preferably greater than $4x10^{-7}$/°C and less than $10x10^{-7}$/°C, and even more preferably greater than $4x10^{-7}$/°C and less than $7x10^{-7}$/°C.

[0021]   There is also provided a method for fabricating the inventive cordierite structure or body by forming a mixture from certain inorganic raw materials having specific particle size restrictions. The inorganic raw materials include talc, silica, and an alumina-forming source. Optionally, the raw material mixture may also contain kaolin. Raw materials are blended together with a pore forming agent, and organic constituents that may include plasticizers, lubricants, and binders. Water is generally added as the solvent. The mixture is shaped into a green body, optionally dried, and then fired to form the product structure.

[0022]   Regarding the inorganic raw materials, the talc, preferably platy (i.e., having a platelet particle morphology), has a median particle size of between 5 and 35 μm, the silica has a median particle size of between 1 and 35 μm, and the alumina source has a median particle size of between 1 and 18 μm. The alumina source is any material that, when heated, is convertible to Al_2O_3, such as but not limited to corundum, aluminum hydroxide, aluminum oxide hydroxide (such as boehmite), and so-called transition aluminas such as gamma-alumina and rho-alumina. If more than one alumina source is used the median particle size is computed as $[w_1(d_{50})_1 + w_2(d_{50})_2 + ... + w_n(d50)_n]/[w_1 + w_2 + ... + w_n]$ where w_i represents the weight percentage of each alumina source and $(d_{50})_i$ is the median particle diameter of the respective alumina source. If kaolin is added it is preferred that the raw material mixture contain not more than about 10 weight percent kaolin, and especially not more than about 5 weight percent kaolin. All particle sizes are measured by a laser diffraction technique.

[0023]   The pore former may be any natural or synthetic material capable of forming relic pores by evaporation or combustion during firing, such as carbon, coke, graphite, starch, flour, cellulose, or a synthetic organic polymer such as a polyacrylate, polyethylene, or polystyrene. The morphology of the pore forming agent may be platey, fibrous, spheroidal,

or other shape. The median particle diameter of the pore forming agent is between 5 μm and 90 μm, preferably between 7 μm and 60 μm, and more preferably between 20 and 50 μm. The pore former is added as a super-addition such that the weight percent super-addition of pore forming agent is computed as 100(mass of pore forming agent)/(mass of cordierite-forming raw materials). All particle sizes are measured by a laser diffraction technique.

[0024] According to the present invention, the talc particle size, the median particle size of the combined alumina sources, the amount of pore former, and the median particle size of the pore former satisfy the relation $R_m \leq -2.64$, where R_m is the raw material parameter defined as being equal to [− 0.102(talc median particle diameter) + 0.001466(talc median particle diameter)^2 − 0.0491((weight percent super-addition of pore forming agent)/(density of pore forming agent)) − 0.00762(median particle diameter of pore forming agent) + 0.0000760(median particle diameter of pore forming agent)^2 − 0.0562(median particle diameter of the alumina sources)]. In the definition of R_m, particle diameters are in units of microns as measured by a laser diffraction technique, and density is in units of grams per cubic centimeter.

[0025] The inorganic raw materials and pore former are intimately blended with a solvent, and forming aids which impart plastic formability and green strength to the raw materials when they are shaped into a body. Forming may be done by, for example, molding or extrusion. When forming is done by extrusion, most typically methyl cellulose serves as a binder, and sodium stearate serves as a lubricant. The relative amounts of forming aids can vary depending on factors such as the nature and amounts of raw materials used, etc. For example, the typical amounts of forming aids are 2% to 10% by weight of methyl cellulose, preferably 3% to 6% by weight, and 0.5% to 2% by weight sodium stearate, preferably 0.6% to 1% by weight. The inorganic raw materials, pore former and the forming aids are mixed together in dry form and then mixed with water as the solvent. The amount of water can vary from one batch of materials to another and therefore is determined by pre-testing the particular batch for extrudability.

[0026] The resulting plastic mixture is then shaped into a green body, preferably a honeycomb structure. The honeycomb structure has an inlet and outlet end or face, and a multiplicity of cells extending from the inlet end to the outlet end, the cells having porous walls. The inventive filters have cellular densities from 70 cells/in^2 (10.9 cells/cm^2) to 400 cells/in^2 (62 cells/cm^2). Extrusion techniques are well known in the art. The green bodies are

dried and then fired at a sufficient temperature and for a sufficient time to form the final product structure. The firing is preferably done by heating to a maximum temperature of 1390° to 1440°C for 4 to 25 hours. The compositions of the present invention result in formation of a ceramic structure which is predominately of a phase approximating the stoichiometry $Mg_2Al_4Si_5O_{18}$.

[0027] Alternate channels of the honeycomb body are plugged at one end, either as part of the honeycomb-forming process, or after drying the unfired body, or after firing the body to form cordierite. A first portion of the cells at the inlet end or face are plugged at the ends, and a second portion of cells at the outlet end or face different from the inlet end cells are additionally plugged so that each cell of the structure is plugged only at one end. The preferred arrangement is to have every other cell on a given face plugged in a checkered pattern.

[0028] To more fully illustrate the invention, the following non-limiting examples are presented below. All parts, portions and percentages are on a weight basis unless otherwise stated.

EXAMPLES

[0029] Inventive and comparative examples are prepared by mixing together selected raw materials from Table 1 in the proportions listed for the examples in Tables 2 to 8. 100 parts by weight of the dry ingredients (oxides plus pore formers) are mixed with about 4 to 6 parts by weight methyl cellulose and 0.5 to 1 part by weight sodium stearate. The contents are then plasticized with about 25 to 40 parts by weight deionized water, and are extruded into honeycomb having a nominal cell density of 200 cells/inch^2 and a wall thickness of 0.012 inches to 0.020 inches. The honeycombs are dried and subsequently fired to a temperature of 1405°C to 1415°C, held at that temperature for 11 to 25 hours, and then cooled to room temperature.

[0030] Properties of comparative (non-inventive) examples are provided in Tables 2 and 3, and properties of inventive examples are given in Tables 4 to 8. Pore volume, %porosity, and pore size distribution are measured by mercury porosimetry. Coefficient of thermal expansion along the axial direction (parallel to the length of the channels) is measured by dilatometry. Modulus of rupture is measured by the four-point method on honeycomb bars

cut parallel to axial direction of the filter. The filter bulk density is estimated from the cell density, wall thickness, and porosity of the materials, assuming a plug depth of 5 mm.

[0031]   Some parts that are approximately 5 cm diameter by approximately 15 cm are plugged at the ends of alternate channels on the opposite faces in a checkered pattern such that a channel that is plugged at one end is open at the other end, thereby forming a wall-flow filter. Pressure drop across the length of the filter is measured at ambient temperature at air flow rates of 11.25 and 26.25 standard cubic feet per minute (scfm). These flow rates are equivalent to 0.319 and 0.743 normal cubic meters per minute, Nm^3/min, respectively. They are also equal to space velocities of approximately 62000 and 144000 $hours^{-1}$, respectively.

[0032]   The filters are then progressively loaded with dry, artificial high surface area carbon soot at a flow rate of approximately 15 scfm (space velocity approximately 85000 hr^{-1}) and at loadings from about 0.5 grams/liter to about 4.5 grams/liter, and the pressure drops are measured at 11.25 and 26.25 scfm for each soot loading. The pressure drop versus soot loading curves for the inventive and comparative examples are shown in FIG. 1. It is evident that the unique pore microstructures of the inventive bodies enable a much lower rate of pressure drop increase with increasing soot loading than the comparative examples. Comparative filters have higher pressure drops because they do not meet both requirements that the bulk filter density be less than 0.60 g/cm^3 and that the value of P_m be no greater than 3.75. The inventive examples are seen to have a much more gradual increase in pressure drop versus soot loading during loading of the initial 1 gram/liter of soot. This results in much lower pressure drops at all higher soot loadings as well.

[0033]   The extrapolated pressure drops at 5 g/l soot loading and 11.25 scfm flow rate are plotted versus the pore microstructural parameter, P_m, in FIG. 2. It is evident that when the value of the parameter P_m is not more than 3.75 and bulk density of the filter is less than 0.60 g/cm^3, the soot-loaded pressure drop of the filter is of a desirable low value.

[0034]   The extrapolated pressure drops at 5 g/l soot loading and 11.25 scfm flow rate are also plotted versus the percentage of total porosity between 10 and 50 μm in FIG. 3. It is apparent that very low pressure drops can be achieved even when the amount of porosity between 10 and 50 μm is much less than 75% of the total amount of porosity in the ceramic. Thus, the pressure drop of a filter cannot be predicted from the amount of porosity between 10 and 50 μm.

[0035] The extrapolated pressure drops at 5 g/l soot loading and 11.25 scfm flow rate are plotted versus the raw material parameter, R_m, in FIG. 4. It is seen that when the raw materials and pore forming agent are selected according to the present invention so that the value of R_m is not more than -2.64, the soot-loaded pressure drop is desirably low.

[0036] Therefore, the present invention is advantageous in providing a lower pressure drop cordierite diesel particulate filter relative to commercially available filters due to improved pore connectivity. The improved pore connectivity is a consequence of the narrow pore size distribution and high %porosity. The inventive filters are especially suitable for applications in which the filter is coated with a catalyst system, however may be used in uncatalyzed applications. The lower pressure drop will enable more efficient operation of the diesel engine and improved fuel economy. Despite having a high porosity, the inventive filters possess a high filtration efficiency since a low pressure drop can be achieved without requiring coarse porosity that would allow the passage of soot particles through the filter walls. The inventive filters also have excellent strength due to the absence of coarse pores, despite a high porosity.

[0037] It should be understood that while the present invention has been described in detail with respect to certain illustrative and specific embodiments thereof, it should not be considered limited to such but may be used in other ways without departing from the spirit of the invention and the scope of the appended claims.

Table 1
Raw material properties

Raw Material	Median Particle Diameter (μm)	Density of Pore Former (g/cm³)
Talc A	24.2	-
Talc B	21.6	-
Talc C	15.4	-
Talc D	68.8	-
Alumina A	6.8	-
Alumina B	1.8	-
Aluminum hydroxide A	13.2	-
Aluminum hydroxide B	5.0	-
Boehmite	< 0.15	-
Kaolin	3.2	-
Silica	23.4	-
Graphite A	124	2.2
Graphite B	49.0	2.2
Graphite C	36.3	2.2
Graphite D	9.0	2.2
Graphite E	28.6	2.2
Potato starch	45.0	1.5
Corn starch	14.6	1.5
Coconut shell flour	36.6	1.3
Walnut shell flour	75	1.3
Porous polyacrylate beads A	8.1	0.8
Porous polyacrylate beads B	41.9	0.8

Table 2
Comparative Examples

Example Number	C1	C2	C3	C4	C5
Talc A	39.96	40.7	40.7	40.7	0
Talc B	0	0	0	0	40.7
Alumina A	21.54	0	0	0	0
Alumina B	0	14.8	14.8	14.8	14.8
Aluminum Hydroxide B	16.35	16.0	16.0	16.0	16.0
Kaolin	0	16.0	16.0	16.0	16.0
Silica	22.15	12.5	12.5	12.5	12.5
Graphite A	0	20.0	0	0	0
Graphite C	10.0	0	0	0	20.0
Graphite E	0	0	20.0	20.0	0
R_m parameter	-2.35	-2.03	-2.41	-2.41	-2.34
Total Intrusion (ml/g)	0.3912	0.3877	0.4246	0.4181	0.3896
% Porosity	47.4	46.6	50.4	49.5	47.2
d_{10} pore size (μm)	7.1	2.0	5.1	5.1	3.0
d_{50} pore size (μm)	12.4	11.1	11.4	11.9	7.1
d_{90} pore size (μm)	23.9	31.2	28.3	35.7	15.4
$(d_{90}-d_{10})/d_{50}$	1.35	2.62	2.03	2.56	1.74
$(d_{90}-d_{50})/d_{50}$	0.92	1.80	1.47	1.99	1.16
$(d_{50}-d_{10})/d_{50}$	0.43	0.82	0.56	0.57	0.58
P_m parameter	3.93	4.75	3.96	4.13	4.15
Pore volume $\geq$ 80 μm (ml/g)	0.0103	0.0120	0.0175	0.0219	0.0053
Pore volume $\geq$ 60 μm (ml/g)	0.0136	0.0164	0.0217	0.0270	0.0070
Pore volume $\geq$ 50 μm (ml/g)	0.0170	0.0216	0.0256	0.0323	0.0089
Pore volume $\geq$ 40 μm (ml/g)	0.0204	0.0268	0.0294	0.0375	0.0107
Pore volume $\geq$ 20 μm (ml/g)	0.0553	0.0800	0.0677	0.0831	0.0265
Pore volume $\geq$ 10 μm (ml/g)	0.2781	0.2176	0.2567	0.2613	0.0880
Pore volume $\geq$ 4 μm (ml/g)	0.3882	0.3121	0.3982	0.3920	0.3166
Pore volume $\geq$ 2 μm (ml/g)	0.3905	0.3499	0.4161	0.4094	0.3740
Percent of total porosity < 10 μm	28.9	43.9	39.5	37.5	77.4
Percent of total porosity > 10 μm, < 50 μm	66.7	50.6	54.4	54.8	20.3
Percent of total porosity > 50 μm	4.3	5.6	6.0	7.7	2.3
Diameter (cm)	5.10	5.05	4.92	5.02	5.20
Length (cm)	15.53	15.18	15.53	15.43	15.97
Cells per square inch	180.6	182	213	198	185
Wall thickness (10^{-3} inches)	19.5	10.9	20.5	13.9	20.5
Filter bulk density (g/cm^3)	0.68	0.43	0.70	0.60	0.71
Clean pressure drop at 11.25 scfm (kPa)	0.73	0.52	1.00	0.49	0.92
Pressure drop at 1 g/L, 11.25 scfm (kPa)	1.62	2.34	2.08	1.45	2.04
Pressure drop at 5 g/L, 11.25 scfm (kPa)	2.97	3.37	3.30	2.24	3.43
Pressure drop at 10 g/L, 11.25 scfm (kPa)	4.83	4.60	5.07	3.22	5.30
Clean pressure drop at 26.25 scfm (kPa)	2.66	1.61	3.62	1.63	2.72
Pressure drop at 1 g/L, 26.25 scfm (kPa)	4.72	6.05	6.21	3.85	5.46
Pressure drop at 5 g/L, 26.25 scfm (kPa)	8.18	8.81	9.61	5.97	9.05
Pressure drop at 10 g/L, 26.25 scfm (kPa)	12.79	11.93	14.27	8.50	13.81
Pressure drop at 1 g/l soot loading minus clean pressure drop, both at 11.25 scfm (kPa)	0.89	1.82	1.08	0.96	1.12
CTE, 25-800°C (10^{-7} °C^{-1})	9.1	3.5	4.7	3.5	6.6
Modulus of rupture on cellular bar (lbs/in^2)	1136	320	-	-	600

Table 3
Comparative Examples

Example Number	C6	C7	C8	C9	C10
Talc A	0	0	0	0	20.35
Talc B	0	40.7	0	0	0
Talc C	40.7	0	40.7	40.7	0
Talc D	0	0	0	0	20.35
Alumina B	14.8	14.8	14.8	14.8	14.8
Aluminum Hydroxide B	16.0	16.0	16.0	16.0	16.0
Kaolin	16.0	16.0	16.0	16.0	16.0
Silica	12.5	12.5	12.5	12.5	12.5
Graphite A	0	0	0	0	40.0
Graphite C	20.0	0	40.0	0	0
Graphite D	0	20.0	0	40.0	0
R_m parameter	-2.04	-2.22	-2.49	-2.37	-2.44
Total Intrusion (ml/g)	0.3838	0.4103	0.5167	0.4868	0.5624
% Porosity	45.6	49.1	52.7	52.7	59.7
d_{10} pore size (μm)	3.5	2.2	4.1	3.7	6.9
d_{50} pore size (μm)	9.4	4.8	9.9	8.4	22.6
d_{90} pore size (μm)	27.4	11.3	35.0	35.1	55.8
$(d_{90}-d_{10})/d_{50}$	2.55	1.92	3.11	3.75	2.16
$(d_{90}-d_{50})/d_{50}$	1.92	1.38	2.53	3.20	1.46
$(d_{50}-d_{10})/d_{50}$	0.63	0.54	0.59	0.56	0.7
P_m parameter	4.51	4.23	3.93	3.91	3.94
Pore volume $\geq$ 80 μm (ml/g)	0.0109	0.0074	0.0170	0.0168	0.0275
Pore volume $\geq$ 60 μm (ml/g)	0.0145	0.0091	0.0248	0.0228	0.048
Pore volume $\geq$ 50 μm (ml/g)	0.0191	0.0107	0.0334	0.0313	0.0777
Pore volume $\geq$ 40 μm (ml/g)	0.0237	0.0123	0.0419	0.0397	0.1073
Pore volume $\geq$ 20 μm (ml/g)	0.0603	0.0224	0.1015	0.0951	0.3243
Pore volume $\geq$ 10 μm (ml/g)	0.1774	0.0483	0.2555	0.2056	0.476
Pore volume $\geq$ 4 μm (ml/g)	0.3309	0.2517	0.4691	0.4247	0.5285
Pore volume $\geq$ 2 μm (ml/g)	0.3700	0.3776	0.5062	0.4779	0.5443
Percent of total porosity < 10 μm	53.8	88.2	50.6	57.8	15.4
Percent of total porosity > 10 μm, < 50 μm	41.2	9.2	43.0	35.8	70.8
Percent of total porosity > 50 μm	5.0	2.6	6.5	6.4	13.8
Diameter (cm)	-	5.37	-	-	5.08
Length (cm)	-	15.15	-	-	15.19
Cells per square inch	-	186	-	-	196
Wall thickness (10^{-3} inches)	-	14.0	-	-	19.9
Filter bulk density (g/cm^3)	-	0.59	-	-	0.52
Clean pressure drop at 11.25 scfm (kPa)	-	1.02	-	-	0.65
Pressure drop at 1 g/L, 11.25 scfm (kPa)	-	1.78	-	-	1.4
Pressure drop at 5 g/L, 11.25 scfm (kPa)	-	3.19	-	-	2.67
Pressure drop at 10 g/L, 11.25 scfm (kPa)	-	5.34	-	-	3.96
Clean pressure drop at 26.25 scfm (kPa)	-	2.85	-	-	2.43
Pressure drop at 1 g/L, 26.25 scfm (kPa)	-	4.67	-	-	4
Pressure drop at 5 g/L, 26.25 scfm (kPa)	-	7.75	-	-	7.52
Pressure drop at 10 g/L, 26.25 scfm (kPa)	-	12.15	-	-	11.32
Pressure drop at 1 g/l soot loading minus clean pressure drop, both at 11.25 scfm (kPa)		0.76	-	-	0.75
CTE, 25-800°C (10^{-7} °C^{-1})	6.4	3.7	8.1	8.6	9.4
Modulus of rupture on cellular bar (lbs/in^2)	-	601	-	-	-

Table 4
Inventive Examples

Example Number	1	2	3	4	5	6
Talc A	40.70	40.70	40.70	39.96	39.96	39.96
Alumina A	0	0	14.80	0	21.54	21.54
Alumina B	14.80	14.80	0	21.54	0	0
Aluminum Hydroxide B	16.00	16.00	16.00	16.35	16.35	16.35
Kaolin	16.00	16.00	16.00	0	0	0
Silica	12.50	12.50	12.50	22.15	22.15	22.15
Graphite A	60.0	0	0	0	0	0
Graphite B	0	0	40.0	40.0	40.0	0
Graphite C	0	0	0	0	0	40.0
Graphite D	0	40.0	0	0	0	0
R_m parameter	-2.92	-2.76	-3.03	-2.87	-3.03	-3.02
Total Intrusion (ml/g)	0.6897	0.5752	0.6140	0.6307	0.5737	0.6195
% Porosity	61.6	59.0	59.9	62.0	55.4	60.7
d_{10} pore size (μm)	5.3	5.0	9.1	9.3	8.7	10.0
d_{50} pore size (μm)	16.9	13.2	15.4	15.9	15.8	17.2
d_{90} pore size (μm)	38.4	39.9	45.0	39.2	35.6	42.2
$(d_{90}-d_{10})/d_{50}$	1.96	2.64	2.34	1.87	1.70	1.88
$(d_{90}-d_{50})/d_{50}$	1.27	2.01	1.93	1.46	1.25	1.45
$(d_{50}-d_{10})/d_{50}$	0.69	0.62	0.41	0.41	0.45	0.42
P_m parameter	3.73	3.66	3.34	3.24	3.59	3.35
Pore volume ≥ 80 μm (ml/g)	0.0203	0.0205	0.0229	0.0250	0.0184	0.0301
Pore volume ≥ 60 μm (ml/g)	0.0321	0.0321	0.0379	0.0362	0.0270	0.0412
Pore volume ≥ 50 μm (ml/g)	0.0479	0.0448	0.0538	0.0491	0.0382	0.0538
Pore volume ≥ 40 μm (ml/g)	0.0637	0.0574	0.0696	0.0619	0.0495	0.0663
Pore volume ≥ 20 μm (ml/g)	0.2491	0.1723	0.2109	0.2195	0.1570	0.2270
Pore volume ≥ 10 μm (ml/g)	0.5423	0.3603	0.5326	0.5531	0.4868	0.5565
Pore volume ≥ 4 μm (ml/g)	0.6401	0.5462	0.6110	0.6273	0.5693	0.6180
Pore volume ≥ 2 μm (ml/g)	0.6728	0.5654	0.6137	0.6302	0.5728	0.6191
Percent of total porosity < 10 μm	21.4	37.4	13.3	12.3	15.1	10.2
Percent of total porosity > 10 μm, < 50 μm	71.7	54.9	78.0	79.9	78.2	81.2
Percent of total porosity > 50 μm	6.9	7.8	8.8	7.8	6.7	8.7
Diameter (cm)	5.15	-	5.12	5.19	5.27	5.34
Length (cm)	15.19	-	15.33	15.05	15.23	15.19
Cells per square inch	179	-	189	164	183	167
Wall thickness (10^{-3} inches)	11.3	-	14.1	13.7	14.2	12.8
Filter bulk density (g/cm^3)	0.31	-	0.40	0.35	0.44	0.35
Clean pressure drop at 11.25 scfm (kPa)	0.43	-	0.43	0.31	0.37	0.30
Pressure drop at 1 g/L, 11.25 scfm (kPa)	1.05	-	0.92	0.56	0.75	0.50
Pressure drop at 5 g/L, 11.25 scfm (kPa)	1.92	-	1.80	1.10	1.70	1.09
Pressure drop at 10 g/L, 11.25 scfm (kPa)	3.01	-	2.99	1.77	2.93	1.79
Clean pressure drop at 26.25 scfm (kPa)	1.60	-	1.57	1.15	1.37	1.14
Pressure drop at 1 g/L, 26.25 scfm (kPa)	3.03	-	2.69	1.70	2.23	1.55
Pressure drop at 5 g/L, 26.25 scfm (kPa)	5.21	-	4.98	3.02	4.58	2.95
Pressure drop at 10 g/L, 26.25 scfm (kPa)	7.90	-	8.04	4.72	7.72	4.73
Pressure drop at 1 g/l soot loading minus clean pressure drop, both at 11.25 scfm (kPa)	0.62	-	0.49	0.25	0.38	0.20
CTE, 25-800°C (10^{-7} °C^{-1})	5.2	5.6	5.5	6.4	7.9	9.5
Modulus of rupture on cellular bar (lbs/in^2)	185	-	-	-	-	305

Table 5
Inventive Examples

Example Number	7	8	9	10	11	12
Talc A	39.96	40.27	39.86	40.7	40.7	40.7
Alumina A	0	10.75	19.05	0	0	0
Alumina B	21.54	0	0	14.8	14.8	14.8
Aluminum Hydroxide B	16.35	15.83	14.01	16.0	16.0	16.0
Boehmite	0	4.95	4.99	0	0	0
Kaolin	0	15.83	0	16.0	16.0	16.0
Silica	22.15	12.37	22.09	12.5	12.5	12.5
Graphite A	0	0	0	0	20.0	0
Graphite C	0	40.0	30.0	0	0	0
Graphite D	40.0	0	0	0	0	0
Potato Starch	0	0	0	40.0	20.0	0
Corn Starch	0	0	0	0	0	40.0
R_m parameter	-2.75	-2.95	-2.75	-3.31	-2.68	-3.21
Total Intrusion (ml/g)	0.5950	0.5385	0.5339	0.6216	0.6561	0.5329
% Porosity	59.8	56.6	54.5	59.4	62.8	56.5
d_{10} pore size (μm)	10.8	7.9	5.0	7.0	7.2	5.0
d_{50} pore size (μm)	20.7	14.6	11.0	14.6	16.0	8.6
d_{90} pore size (μm)	53.8	39.3	30.4	29.2	35.5	34.5
$(d_{90}-d_{10})/d_{50}$	2.08	2.15	2.31	1.52	1.77	3.42
$(d_{90}-d_{50})/d_{50}$	1.60	1.69	1.76	1.00	1.22	2.99
$(d_{50}-d_{10})/d_{50}$	0.48	0.46	0.55	0.52	0.55	0.42
P_m parameter	3.55	3.55	3.69	3.41	3.42	3.43
Pore volume $\geq$ 80 μm (ml/g)	0.0347	0.0238	0.0182	0.0140	0.0161	0.0170
Pore volume $\geq$ 60 μm (ml/g)	0.0503	0.0320	0.0246	0.0209	0.0245	0.0255
Pore volume $\geq$ 50 μm (ml/g)	0.0693	0.0420	0.0315	0.0287	0.0333	0.0340
Pore volume $\geq$ 40 μm (ml/g)	0.0882	0.0520	0.0383	0.0364	0.0421	0.0424
Pore volume $\geq$ 20 μm (ml/g)	0.3119	0.1527	0.0939	0.1457	0.1664	0.0895
Pore volume $\geq$ 10 μm (ml/g)	0.5553	0.4211	0.3042	0.4917	0.5344	0.2115
Pore volume $\geq$ 4 μm (ml/g)	0.5942	0.5305	0.5023	0.5903	0.6301	0.5091
Pore volume $\geq$ 2 μm (ml/g)	0.5942	0.5370	0.5217	0.6018	0.6422	0.5287
Percent of total porosity < 10 μm	6.7	21.8	43.0	20.9	18.5	60.3
Percent of total porosity > 10 μm, < 50 μm	81.7	70.4	51.1	74.5	76.4	33.3
Percent of total porosity > 50 μm	11.6	7.8	5.9	4.6	5.1	6.4
Diameter (cm)	-	5.14	4.92	5.16	-	5.08
Length (cm)	-	15.26	15.24	15.21	-	15.24
Cells per square inch	-	186	188	197	-	205
Wall thickness (10^{-3} inches)	-	13.4	12.2	11.5	-	11.7
Filter bulk density (g/cm^3)	-	0.41	0.40	0.35	-	0.39
Clean pressure drop at 11.25 scfm (kPa)	-	0.37	0.43	0.40	-	0.41
Pressure drop at 1 g/L, 11.25 scfm (kPa)	-	0.67	0.87	0.97	-	0.72
Pressure drop at 5 g/L, 11.25 scfm (kPa)	-	1.34	1.62	1.95	-	1.37
Pressure drop at 10 g/L, 11.25 scfm (kPa)	-	2.23	2.58	3.26	-	2.18
Clean pressure drop at 26.25 scfm (kPa)	-	1.37	1.46	1.48	-	1.44
Pressure drop at 1 g/L, 26.25 scfm (kPa)	-	2.03	2.48	2.81	-	2.13
Pressure drop at 5 g/L, 26.25 scfm (kPa)	-	3.69	4.34	5.29	-	3.73
Pressure drop at 10 g/L, 26.25 scfm (kPa)	-	6.02	6.71	8.61	-	5.83
Pressure drop at 1 g/l soot loading minus clean pressure drop, both at 11.25 scfm (kPa)		0.30	0.44	0.57	-	0.31
CTE, 25-800°C (10^{-7} °C^{-1})	7.8	7.5	5.2	4.2	3.2	4.3
Modulus of rupture on cellular bar (lbs/in^2)	-	409	247	253	-	236

Table 6
Inventive Examples

Example Number	13	14	15	16	17	18
Talc A	0	0	0	0	0	40.7
Talc B	40.7	40.7	0	0	40.7	0
Talc C	0	0	40.7	40.7	0	0
Alumina B	14.8	14.8	14.8	14.8	14.8	14.8
Aluminum Hydroxide B	16.0	16.0	16.0	16.0	16.0	16.0
Kaolin	16.0	16.0	16.0	16.0	16.0	16.0
Silica	12.5	12.5	12.5	12.5	12.5	12.5
Graphite A	0	0	0	0	0	30.0
Graphite C	60.0	0	60.0	0	35.0	0
Graphite D	0	60.0	0	60.0	0	0
Potato Starch	0	0	0	0	0	20.0
R_m parameter	-3.23	-3.12	-2.93	-2.82	-2.67	-2.91
Total Intrusion (ml/g)	0.6640	0.6709	0.6775	0.6081	0.5989	0.9012
% Porosity	62.2	58.4	61.3	55.7	60.0	69.7
d_{10} pore size (μm)	6.2	3.5	4.1	3.7	4.6	7.6
d_{50} pore size (μm)	11.7	6.3	9.1	7.8	12.3	18.6
d_{90} pore size (μm)	21.5	15.7	25.7	38.6	29.3	51.7
$(d_{90}-d_{10})/d_{50}$	1.32	1.96	2.37	4.48	2.01	2.37
$(d_{90}-d_{50})/d_{50}$	0.85	1.51	1.81	3.96	1.38	1.78
$(d_{50}-d_{10})/d_{50}$	0.47	0.45	0.55	0.52	0.63	0.59
P_m parameter	3.04	3.21	3.29	3.70	3.52	3.34
Pore volume ≥ 80 μm (ml/g)	0.0092	0.0157	0.0141	0.0270	0.0139	0.0271
Pore volume ≥ 60 μm (ml/g)	0.0141	0.0190	0.0211	0.0369	0.0183	0.0405
Pore volume ≥ 50 μm (ml/g)	0.0192	0.0226	0.0290	0.0489	0.0233	0.0651
Pore volume ≥ 40 μm (ml/g)	0.0243	0.0261	0.0368	0.0609	0.0283	0.0898
Pore volume ≥ 20 μm (ml/g)	0.0791	0.0490	0.0930	0.1343	0.0874	0.3517
Pore volume ≥ 10 μm (ml/g)	0.4291	0.1154	0.2974	0.2499	0.3881	0.6650
Pore volume ≥ 4 μm (ml/g)	0.6446	0.5598	0.6093	0.6079	0.5556	0.7780
Pore volume ≥ 2 μm (ml/g)	0.6575	0.6574	0.6631	0.6081	0.5891	0.7962
Percent of total porosity < 10 μm	35.4	82.8	56.1	58.9	35.2	26.2
Percent of total porosity > 10 μm, < 50 μm	61.7	13.8	39.6	33.1	60.9	66.6
Percent of total porosity > 50 μm	2.9	3.4	4.3	8.0	3.9	7.2
Diameter (cm)	5.16	5.35	5.23	5.39	-	-
Length (cm)	15.22	15.23	15.20	15.22	-	-
Cells per square inch	186	190	183	202	-	-
Wall thickness (10^{-3} inches)	11.7	12.6	14.4	11.3	-	-
Filter bulk density (g/cm^3)	0.32	0.38	0.39	0.38	-	-
Clean pressure drop at 11.25 scfm (kPa)	0.50	0.53	0.47	0.40	-	-
Pressure drop at 1 g/L, 11.25 scfm (kPa)	0.92	0.86	0.90	0.70	-	-
Pressure drop at 5 g/L, 11.25 scfm (kPa)	1.93	1.68	1.85	1.18	-	-
Pressure drop at 10 g/L, 11.25 scfm (kPa)	3.26	2.76	3.09	1.72	-	-
Clean pressure drop at 26.25 scfm (kPa)	1.78	1.76	1.62	1.40	-	-
Pressure drop at 1 g/L, 26.25 scfm (kPa)	2.71	2.54	2.61	2.11	-	-
Pressure drop at 5 g/L, 26.25 scfm (kPa)	5.28	4.50	5.01	3.46	-	-
Pressure drop at 10 g/L, 26.25 scfm (kPa)	8.64	7.13	8.18	5.04	-	-
Pressure drop at 1 g/l soot loading minus clean pressure drop, both at 11.25 scfm (kPa)	0.42	0.33	0.43	0.30	-	-
CTE, 25-800°C (10^{-7} °C^{-1})	6.4	5.1	7.3	-	6.3	-
Modulus of rupture on cellular bar (lbs/in^2)	270	238	276	264	330	-

Table 7
Inventive Examples

Example Number	19	20	21	22	23
Talc A	40.7	40.7	40.7	40.7	40.7
Alumina B	14.8	14.8	14.8	14.8	14.8
Aluminum Hydroxide B	16.0	16.0	16.0	16.0	16.0
Kaolin	16.0	16.0	16.0	16.0	16.0
Silica	12.5	12.5	12.5	12.5	12.5
Graphite A	40.0	0	0	0	0
Potato Starch	20.0	0	0	0	0
Coconut shell flour	0	36.0	0	0	0
Walnut shell flour	0	0	36.0	0	0
Polyacrylate beads A	0	0	0	30.0	0
Polyacrylate beads B	0	0	0	0	30.0
R_m parameter	-3.13	-3.34	-3.18	-3.70	-3.83
Total Intrusion (ml/g)	0.8301	0.5862	0.6392	0.4881	0.5473
% Porosity	70.5	63.7	61.02	55.0	57.9
d_{10} pore size (μm)	7.0	4.9	4.9	2.4	3.6
d_{50} pore size (μm)	17.4	9.4	12.1	5.4	10.7
d_{90} pore size (μm)	36.8	15.4	23.4	17.0	23.9
$(d_{90}-d_{10})/d_{50}$	1.71	1.13	1.52	2.69	1.90
$(d_{90}-d_{50})/d_{50}$	1.12	0.64	0.93	2.13	1.23
$(d_{50}-d_{10})/d_{50}$	0.60	0.48	0.59	0.56	0.67
P_m parameter	3.28	2.87	3.33	3.75	3.59
Pore volume $\geq$ 80 μm (ml/g)	0.0244	0.0108	0.0140	0.0091	0.0123
Pore volume $\geq$ 60 μm (ml/g)	0.0379	0.0151	0.0190	0.0126	0.0172
Pore volume $\geq$ 50 μm (ml/g)	0.0549	0.0179	0.0245	0.0157	0.0219
Pore volume $\geq$ 40 μm (ml/g)	0.0718	0.0207	0.0300	0.0188	0.0266
Pore volume $\geq$ 20 μm (ml/g)	0.2870	0.0405	0.0890	0.0393	0.0750
Pore volume $\geq$ 10 μm (ml/g)	0.6834	0.2474	0.4050	0.1086	0.3017
Pore volume $\geq$ 4 μm (ml/g)	0.7912	0.5493	0.5975	0.3216	0.4840
Pore volume $\geq$ 2 μm (ml/g)	0.8082	0.5761	0.6252	0.4579	0.5230
Percent of total porosity < 10 μm	17.7	57.8	36.6	77.8	44.9
Percent of total porosity > 10 μm, < 50 μm	75.7	39.1	59.5	19.0	51.1
Percent of total porosity > 50 μm	6.6	3.1	3.8	3.2	4.0
CTE, 25-800°C (10^{-7} °C^{-1})	6.1	-	8.3	-	-
Modulus of rupture on cellular bar (lbs/in^2)	-	-	-	-	-

Table 8
Inventive Examples

Example Number	24	25	26	27
Talc A	40.7	40.7	40.7	40.7
Alumina A	16.0	16.0	0	0
Alumina B	0	0	16.0	16.0
Aluminum Hydroxide A	16.0	16.0	0	0
Aluminum Hydroxide B	0	0	16.0	16.0
Kaolin	16.0	16.0	16.0	16.0
Silica	12.5	12.5	12.5	12.5
Graphite E	20.0	40.0	40.0	60.0
R_m parameter	-2.78	-3.23	-2.86	-3.30
Total Intrusion (ml/g)	0.4820	0.6037	0.4759	0.5966
% Porosity	55.2	61.1	53.2	60.8
d_{10} pore size (μm)	8.2	10.1	7.8	8.8
d_{50} pore size (μm)	14.6	16.0	12.5	13.6
d_{90} pore size (μm)	29.8	32.2	28.4	29.8
$(d_{90}-d_{10})/d_{50}$	1.48	1.38	1.65	1.55
$(d_{90}-d_{50})/d_{50}$	1.04	1.02	1.28	1.19
$(d_{50}-d_{10})/d_{50}$	0.44	0.37	0.38	0.35
P_m parameter	3.50	3.16	3.48	3.07
Pore volume $\geq$ 80 μm (ml/g)	0.0150	0.0185	0.0161	0.0188
Pore volume $\geq$ 60 μm (ml/g)	0.0208	0.0268	0.0210	0.0241
Pore volume $\geq$ 50 μm (ml/g)	0.0257	0.0340	0.0260	0.0303
Pore volume $\geq$ 40 μm (ml/g)	0.0332	0.0446	0.0318	0.0372
Pore volume $\geq$ 20 μm (ml/g)	0.0966	0.1471	0.0786	0.1052
Pore volume $\geq$ 10 μm (ml/g)	0.3988	0.5452	0.3442	0.4851
Pore volume $\geq$ 4 μm (ml/g)	0.4716	0.5941	0.4728	0.5942
Pore volume $\geq$ 2 μm (ml/g)	0.4787	0.5983	0.4752	0.5961
Percent of total porosity < 10 μm	17.3	9.7	27.7	18.7
Percent of total porosity > 10 μm, < 50 μm	77.4	84.7	66.9	76.2
Percent of total porosity > 50 μm	5.3	5.6	5.5	5.1
Diameter (cm)	-	-	5.07	-
Length (cm)	-	-	15.33	-
Cells per square inch	-	-	196	-
Wall thickness (10^{-3} inches)	-	-	13.7	-
Filter bulk density (g/cm^3)	-	-	0.46	-
Clean pressure drop at 11.25 scfm (kPa)	-	-	0.50	-
Pressure drop at 1 g/L, 11.25 scfm (kPa)	-	-	1.18	-
Pressure drop at 5 g/L, 11.25 scfm (kPa)	-	-	2.11	-
Pressure drop at 10 g/L, 11.25 scfm (kPa)	-	-	3.30	-
Clean pressure drop at 26.25 scfm (kPa)	-	-	1.78	-
Pressure drop at 1 g/L, 26.25 scfm (kPa)	-	-	3.32	-
Pressure drop at 5 g/L, 26.25 scfm (kPa)	-	-	5.74	-
Pressure drop at 10 g/L, 26.25 scfm (kPa)	-	-	8.84	-
Pressure drop at 1 g/l soot loading minus clean pressure drop, both at 11.25 scfm (kPa)	-	-	0.68	-
CTE, 25-800°C (10^{-7} °C^{-1})	5.5	6.0	5.3	7.4
Modulus of rupture on cellular bar (lbs/in^2)	-	-	-	-